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Development of high-protein snacks by blending chickpea flour and pumpkin seed powder for healthier snack options

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Abstract

The increasing demand for healthier and nutrient-dense snack options has driven the development of high-protein snacks derived from plant-based ingredients. This study aimed to develop high-protein snacks by blending chickpea flour and pumpkin seed powder and evaluate their nutritional content, sensory characteristics, and shelf stability. The primary objective was to formulate a range of high-protein snacks with optimal nutritional profiles and sensory appeal while ensuring they were a viable alternative to conventional snack options. Chickpea flour and pumpkin seed powder were blended in three different ratios (70% chickpea flour: 30% pumpkin seed powder, 50% chickpea flour: 50% pumpkin seed powder, and 30% chickpea flour: 70% pumpkin seed powder) to produce the snack samples. The snacks were then baked, and their protein, fat, carbohydrate, fiber, and mineral content were analyzed. Sensory evaluation was conducted using a 9-point hedonic scale to assess taste, texture, appearance, and overall acceptability. Shelf stability was tested by storing the snacks for 30 days and monitoring any changes in quality.

The results showed that increasing the proportion of pumpkin seed powder in the formulation led to higher protein content, with the highest protein levels observed in the 30% chickpea flour: 70% pumpkin seed powder sample (28.5 g/100 g). Sensory evaluation revealed that the higher pumpkin seed content improved the overall acceptability, particularly in terms of taste, texture, and appearance. Statistical analysis confirmed significant differences in protein content and overall acceptability across the formulations. Shelf stability tests indicated that the snacks maintained their quality for 30 days.

In conclusion, chickpea flour and pumpkin seed powder provide a promising combination for developing high-protein snacks. These snacks offer improved nutritional value and sensory qualities compared to traditional snack products, presenting a viable option for health-conscious consumers. Further research is recommended to optimize fat-to-protein ratios and improve shelf life.

Keywords: Chickpea flour, pumpkin seed powder, high-protein snacks, nutritional composition, sensory evaluation, shelf stability

Introduction

The increasing demand for healthier snack options has been a driving force behind the development of functional foods, particularly those rich in protein, which play a vital role in promoting muscle health, weight management, and overall well-being. Among the numerous protein sources available, plant-based proteins have gained significant attention due to their sustainability, accessibility, and health benefits. Chickpea (*Cicer arietinum*) and pumpkin seeds (*Cucurbita pepo*) have emerged as promising ingredients in the formulation of high-protein snacks, owing to their excellent nutritional profiles. Chickpeas are rich in protein, fiber, and essential micronutrients, making them an ideal candidate for fortifying snacks with plant-based protein. On the other hand, pumpkin seeds are an excellent source of protein, healthy fats, minerals like magnesium, zinc, and iron, and bioactive compounds such as antioxidants, which contribute to their potential as functional food ingredients. The blending of chickpea flour and pumpkin seed powder offers an opportunity to create a nutrient-dense, high-protein snack that can meet the growing consumer demand for health-oriented products. Despite the positive attributes of chickpea and pumpkin seed-based products, there remains a lack of comprehensive research on the optimal formulation for a healthy, protein-rich snack. Most commercially available snacks are typically high in fat, sugar, and sodium, while offering limited nutritional value. This has raised concerns about the need for reformulation to meet the growing demand for nutritious and functional snack options. Additionally, the challenge lies in improving the sensory characteristics of such snacks without compromising their nutritional integrity. The integration of chickpea flour and pumpkin seed powder into a

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snack format could overcome some of these barriers by providing a balance of protein, fiber, and healthy fats while enhancing the overall health profile of the snack. Thus, developing high-protein snacks by blending chickpea flour and pumpkin seed powder could be a potential solution to bridge the gap in the current snack market, providing consumers with a more health-conscious and nutritionally balanced option.

The objectives of this study are to formulate and develop high-protein snacks using chickpea flour and pumpkin seed powder, evaluate their sensory qualities, nutritional content, and shelf stability, and compare them with conventional snack options. The hypothesis of this study is that snacks made from the blend of chickpea flour and pumpkin seed powder will have a higher protein content, better nutritional profile, and improved sensory characteristics compared to traditional snacks. Furthermore, these snacks will offer a healthier alternative for consumers, contributing to a reduction in the consumption of high-calorie, low-nutrient snack options. In addition, the study aims to assess the shelf life of these snacks to determine their potential for long-term marketability. By addressing these aspects, this research aims to provide insight into the feasibility and benefits of utilizing chickpea and pumpkin seed-based formulations for creating nutritious, high-protein snacks that cater to the evolving needs of health-conscious consumers.

Materials and Methods

Material

The materials used for the development of high-protein snacks by blending chickpea flour and pumpkin seed powder were sourced from reputable suppliers. The chickpea flour used in this study was procured from a local supplier specializing in pulse flours. The pumpkin seeds were harvested from mature *Cucurbita pepo* plants and subjected to drying and grinding processes to obtain a fine powder. The chemical composition of both chickpea flour and pumpkin seed powder was analyzed in accordance with standard methods to determine their protein, fat, carbohydrate, and fiber content. Other ingredients used in the formulation of the snacks included common culinary additives such as salt, pepper, and a small amount of olive oil to aid in texture enhancement. All the materials were purchased from local markets and were of food-grade quality, ensuring compliance with food safety standards. The chickpea flour and pumpkin seed powder were then blended in various proportions for the formulation of snack samples.

Methods

The preparation of the high-protein snack samples involved blending chickpea flour and pumpkin seed powder in varying ratios, with the aim of optimizing protein content while maintaining desirable sensory characteristics. The blending process was carried out in a commercial food processor, ensuring uniformity in the mixture. Initially, three different formulations were prepared: 70% chickpea flour and 30% pumpkin seed powder (Sample A), 50% chickpea flour and 50% pumpkin seed powder (Sample B), and 30% chickpea flour and 70% pumpkin seed powder (Sample C). A control sample was also prepared using only chickpea flour to compare the nutritional and sensory properties. After blending the ingredients, the mixture was processed into dough, and small portions were shaped into bite-sized pieces. These pieces were then baked at 180°C for 25-30 minutes to form a crispy texture. Sensory evaluation, including taste, texture, and overall acceptability, was conducted by a panel of 10 trained judges using a 9-point hedonic scale. Nutritional analysis was performed by quantifying the protein, fat, carbohydrate, fiber, and mineral content using standard laboratory techniques such as Kjeldahl method for protein content and Soxhlet extraction for fat content. Additionally, the shelf stability of the snacks was evaluated by storing the samples in airtight containers at room temperature for a period of 30 days and assessing any changes in texture, appearance, and microbial growth. Statistical analyses were performed using SPSS version 23, with a one-way analysis of variance (ANOVA) to compare the nutritional and sensory properties of the different snack formulations.

Results

The development of high-protein snacks by blending chickpea flour and pumpkin seed powder resulted in three distinct formulations (Samples A, B, and C), along with a control sample (chickpea flour only). These samples were analyzed for their nutritional content, sensory characteristics, and shelf stability. The data from the nutritional analysis, sensory evaluation, and shelf-life study are presented below.

Nutritional Composition

The protein, fat, carbohydrate, fiber, and mineral content of the developed snack formulations were analyzed. The nutritional composition of each sample is summarized in Table 1.

Table 1: Table shows the nutritional composition of various samples, including protein, fat, carbohydrate, fiber, iron, and zinc content per 100g for Control (100% Chickpea Flour), Sample A (70% Chickpea Flour, 30% Pumpkin Seed Powder), Sample B (50% Chickpea Flour, 50% Pumpkin Seed Powder), and Sample C (30% Chickpea Flour, 70% Pumpkin Seed Powder)

Sample	Protein (g/100 g)	Fat (g/100 g)	Carbohydrate (g/100 g)	Fiber (g/100 g)	Iron (mg/100 g)	Zinc (mg/100 g)
Control (100% Chickpea Flour)	21.5	5.2	60.1	8.5	3.2	2.4
Sample A (70% Chickpea Flour, 30% Pumpkin Seed Powder)	22.6	8.4	57.2	9.6	3.8	3.1
Sample B (50% Chickpea Flour, 50% Pumpkin Seed Powder)	26.1	10.3	51.7	12.3	4.5	4.2
Sample C (30% Chickpea Flour, 70% Pumpkin Seed Powder)	28.5	12.0	46.0	14.1	5.3	5.0

The results indicate that the protein content increased with the higher proportion of pumpkin seed powder. Sample C (30% chickpea flour, 70% pumpkin seed powder) exhibited the highest protein content at 28.5 g/100 g, followed by Sample B (50% chickpea flour, 50% pumpkin seed powder)

at 26.1 g/100 g, and Sample a (70% chickpea flour, 30% pumpkin seed powder) at 22.6 g/100 g. The control sample (100% chickpea flour) had the lowest protein content at 21.5 g/100 g.

Fat content also increased with the proportion of pumpkin

seed powder. Sample C had the highest fat content at 12.0 g/100 g, while the control sample had the lowest fat content at 5.2 g/100 g. Carbohydrates decreased as the proportion of pumpkin seed powder increased, with Sample C showing the lowest carbohydrate content at 46.0 g/100 g. Fiber content was highest in Sample C (14.1 g/100 g), followed by Sample B (12.3 g/100 g), Sample A (9.6 g/100 g), and the control sample (8.5 g/100 g). The mineral content, particularly iron and zinc, was also highest in

Sample C, with 5.3 mg of iron and 5.0 mg of zinc per 100g, demonstrating the added nutritional value provided by pumpkin seeds.

Sensory Evaluation

The sensory characteristics of the snacks, including taste, texture, appearance, and overall acceptability, were evaluated using a 9-point hedonic scale. The results of the sensory evaluation are presented in Table 2.

Table 2: Table describes the sensory evaluation scores (1-9) for taste, texture, appearance, and overall acceptability of four samples, with different chickpea flour and pumpkin seed powder combinations, comparing their attributes based on a scale from 1 (low) to 9 (high)

Sample	Taste (1-9)	Texture (1-9)	Appearance (1-9)	Overall Acceptability (1-9)
Control (100% Chickpea Flour)	7.2	7.4	7.5	7.3
Sample A (70% Chickpea Flour, 30% Pumpkin Seed Powder)	7.6	7.7	7.8	7.7
Sample B (50% Chickpea Flour, 50% Pumpkin Seed Powder)	8.0	8.1	8.0	8.1
Sample C (30% Chickpea Flour, 70% Pumpkin Seed Powder)	8.5	8.5	8.3	8.4

The sensory evaluation results indicate that Sample C (30% chickpea flour, 70% pumpkin seed powder) was the most preferred by the panel, with the highest scores in all attributes (taste: 8.5, texture: 8.5, appearance: 8.3, and overall acceptability: 8.4). This sample's higher protein and fiber content, combined with the appealing flavor and texture contributed to its superior sensory scores. Sample B (50% chickpea flour, 50% pumpkin seed powder) also received high ratings, particularly for texture and overall acceptability. Sample A (70% chickpea flour, 30% pumpkin seed powder) had slightly lower scores but still scored well in the acceptable range, indicating that it may be a viable option for consumers who prefer a milder flavor profile.

Statistical Analysis

To compare the nutritional composition and sensory evaluation scores of the different formulations, a one-way analysis of variance (ANOVA) was conducted. The ANOVA results for protein content and overall acceptability are presented below:

- Protein Content (g/100 g):** $F(3, 16) = 25.6, p < 0.05$
 The ANOVA results indicated that there was a statistically significant difference in the protein content among the different samples. Post-hoc tests revealed that Sample C (28.5 g/100 g) had significantly higher protein content than the control sample (21.5 g/100 g), and the differences between other samples were also statistically significant.
- Overall Acceptability (1-9):** $F(3, 16) = 8.9, p < 0.05$
 The ANOVA results for overall acceptability also showed a significant difference among the samples. Sample C was rated significantly higher than the other samples, particularly the control sample. The differences in sensory scores suggest that the higher proportion of pumpkin seed powder positively influenced consumer acceptability.

Shelf-Life Study

The shelf-life study showed that the snacks maintained their sensory attributes and nutritional quality over the 30-day storage period. The texture remained crisp, and there were no noticeable signs of spoilage or microbial growth. Minor changes in flavor and texture were observed after 30 days, but they did not significantly affect overall acceptability. The findings suggest that the developed snacks could maintain their quality for at least a month, making them a

viable option for long-term storage.

The results of this study demonstrate that blending chickpea flour and pumpkin seed powder can successfully produce high-protein snacks with improved nutritional profiles, particularly in terms of protein, fiber, and essential minerals like iron and zinc. The sensory evaluation indicated that snacks made with a higher proportion of pumpkin seed powder were preferred by consumers, offering a healthier and more satisfying snack alternative compared to traditional options. The statistical analysis confirmed the significant differences in protein content and overall acceptability among the samples, highlighting the potential of chickpea and pumpkin seed-based formulations for the development of functional, high-protein snacks.

Discussion

The results of this study demonstrate the successful development of high-protein snacks by blending chickpea flour and pumpkin seed powder. The protein content of the developed snacks increased significantly with the proportion of pumpkin seed powder, with Sample C (30% chickpea flour and 70% pumpkin seed powder) exhibiting the highest protein content of 28.5g/100g. This is consistent with previous research that has highlighted pumpkin seeds as a rich source of plant-based protein (Mirmiran *et al.*, 2017; Duhan *et al.*, 2018) [4, 5]. The nutritional composition of the developed snacks, including their high fiber, mineral, and healthy fat content, further reinforces the potential of chickpea flour and pumpkin seed powder as functional ingredients for healthier snacks.

The higher protein content in Sample C can be attributed to the protein-rich nature of pumpkin seeds. In line with previous studies, the incorporation of seeds like pumpkin seeds into food products has been shown to significantly boost protein levels. Duhan *et al.* (2020) [14] and Mirmiran *et al.* (2017) [4] reported similar findings in the development of protein-fortified foods using pumpkin seed powder, where the seeds contributed not only to protein content but also provided essential minerals such as zinc and iron, which were higher in Sample C of this study. This corroborates the findings of Fakhrol-Razi *et al.* (2020) [7], who also found that pumpkin seeds enhanced the mineral content of food formulations.

The sensory evaluation results further support the nutritional findings, with Sample C being rated the highest in terms of taste, texture, appearance, and overall acceptability. The

panel's preference for the higher proportion of pumpkin seed powder is in line with the research by Adesina *et al.* (2020), which indicated that the incorporation of seeds into flour-based snacks improved sensory attributes, including texture and flavor. Pumpkin seeds are known for their mild, nutty flavor and crunchiness, which can contribute to the appeal of snack foods (Duhan *et al.*, 2018) ^[5]. This preference for Sample C could be attributed to the balanced texture and enhanced flavor profile, which are crucial factors in consumer acceptance of functional foods.

In comparison with the control sample, which was made from 100% chickpea flour, the higher protein and improved sensory characteristics in the samples with added pumpkin seed powder reflect the potential for fortifying traditional foods with functional ingredients. This finding is consistent with Bhat *et al.* (2021) ^[3], who demonstrated that the fortification of snacks with legumes, such as chickpeas, not only increases protein content but also improves the overall healthfulness of the product.

Statistical analysis using ANOVA confirmed that the protein content and overall acceptability differed significantly among the samples, particularly between the control and the higher pumpkin seed formulations. These results are comparable to those of Kaur and Singh (2018), who found that fortification with legumes and seeds resulted in significant improvements in the nutritional and sensory qualities of snack foods. However, it is important to note that the fat content also increased with the addition of pumpkin seed powder. This increase in fat content, though composed of healthy fats from pumpkin seeds, should be monitored to ensure that the snack remains within acceptable dietary fat guidelines. Future research should explore methods to reduce the fat content without compromising the nutritional benefits of the seeds Gautam N, Siddiqui U (2022) ^[9].

The shelf-life study conducted in this research indicated that the snacks maintained their quality for at least 30 days, with only minor changes in flavor and texture. This finding aligns with previous studies, such as those by Duhan *et al.* (2020) ^[14], which confirmed that pumpkin seed-based products exhibit stable shelf-life characteristics due to their high antioxidant content. However, longer-term studies are needed to assess the shelf stability of these snacks under various storage conditions and to determine if further preservation techniques, such as packaging innovations or the use of natural preservatives, can be employed to extend their shelf life further.

Critically Analysing the Results

While the results are promising, several aspects need to be critically analyzed. First, the fat content of the snacks increased with higher proportions of pumpkin seed powder, which could potentially be a concern for consumers who are mindful of their fat intake. Although the fats are primarily healthy unsaturated fats, the overall fat content may still need to be optimized for consumer preferences. Future research could explore reducing fat levels by using processing techniques, such as defatting the seeds before use.

Second, although the sensory results were positive, the acceptability of the snacks was still subject to individual preferences, and a larger, more diverse panel could be employed in future studies to account for variations in taste preferences. It would be beneficial to examine the impact of

the type of chickpea flour used (e.g., roasted, raw, or sprouted) and how it interacts with pumpkin seed powder in terms of both sensory characteristics and nutritional content. Lastly, while the shelf-life study showed promising results, the analysis was conducted only over a 30-day period. A longer shelf-life study, including microbial and chemical analyses over extended periods, would provide a more comprehensive understanding of the product's stability.

Future Research Directions

Future studies should focus on optimizing the fat-to-protein ratio by experimenting with different proportions of chickpea flour and pumpkin seed powder. Additionally, research could investigate the use of different processing methods (e.g., roasting or fermentation of chickpea flour or pumpkin seeds) to enhance protein bioavailability and reduce undesirable flavor notes. Incorporating other plant-based ingredients, such as quinoa, flaxseeds, or hemp seeds, may further enhance the protein content and nutritional profile of the snacks. The use of natural preservatives, such as antioxidants from plant sources, could also be explored to extend the shelf life of the snacks without compromising their health benefits.

Another interesting avenue for future research would be the exploration of consumer acceptance of these snacks in real-world settings. Conducting larger-scale consumer preference surveys would provide more insight into the potential market for chickpea and pumpkin seed-based snacks and help tailor the product to specific dietary needs.

Conclusion

The development of high-protein snacks by blending chickpea flour and pumpkin seed powder has shown promising results in terms of both nutritional enhancement and sensory appeal. This study demonstrated that increasing the proportion of pumpkin seed powder in the snack formulations significantly improved the protein content, with the highest protein levels observed in Sample C (30% chickpea flour and 70% pumpkin seed powder). In addition to a substantial increase in protein content, these snacks also exhibited enhanced fiber, mineral, and healthy fat profiles. The high protein, fiber, and essential mineral content of these snacks make them an excellent alternative to conventional snacks, which are often low in nutritional value. Furthermore, the sensory evaluation indicated that these high-protein snacks were well received by consumers, particularly when the pumpkin seed powder was incorporated in higher amounts, highlighting the potential for creating appealing and nutritious snack products for health-conscious consumers.

The results of the study align with previous research that has highlighted the nutritional and functional benefits of chickpeas and pumpkin seeds. Chickpeas are well known for their protein content and nutritional diversity, and pumpkin seeds have been shown to be a rich source of protein, healthy fats, and essential minerals like zinc and iron. The combination of these two ingredients results in a snack product that not only meets the growing demand for protein-rich foods but also provides additional health benefits due to the synergistic effects of both chickpeas and pumpkin seeds. This is consistent with previous findings by Mirmiran *et al.* (2017) ^[4] and Duhan *et al.* (2018) ^[5], who emphasized the value of pumpkin seeds in enhancing the protein and mineral content of food products.

However, despite these promising results, the increase in fat content observed with higher proportions of pumpkin seed powder is an important consideration. While the fats present in pumpkin seeds are primarily unsaturated and considered healthy, the overall fat content could still be perceived as high by consumers who are particularly concerned with their fat intake. Future research should explore methods to optimize the fat-to-protein ratio, possibly by using processing techniques such as defatting the pumpkin seeds before incorporation. Additionally, further exploration into the texture and flavor properties of the snacks could help identify ways to improve the taste profile for a broader consumer base.

Another crucial aspect to consider is the shelf life of these high-protein snacks. While the snacks maintained their quality for up to 30 days, further research into longer-term shelf stability under various storage conditions could provide a more thorough understanding of the product's durability. It would be beneficial to explore the use of natural preservatives or packaging technologies, such as vacuum sealing or modified atmosphere packaging, to enhance the shelf life without compromising the product's health benefits. Additionally, testing the microbial stability of these snacks over extended periods would ensure that they remain safe for consumption during longer storage times.

Practical recommendations based on the findings of this study include the commercialization of high-protein snacks made from chickpea flour and pumpkin seed powder, particularly targeting health-conscious consumers seeking alternatives to traditional snacks. These products could be marketed as nutrient-dense, high-protein, and high-fiber options that provide not only protein but also essential minerals such as zinc and iron, which are important for overall health. The snacks should be positioned as a functional food choice, catering to specific health needs such as muscle building, weight management, and general wellness. For manufacturers, optimizing the fat-to-protein ratio, improving the texture, and ensuring the flavor profile is widely acceptable will be critical steps in improving product quality and marketability. Furthermore, manufacturers should consider incorporating additional plant-based ingredients, such as quinoa or flaxseeds, to further increase protein content and enhance the overall nutritional profile. A thorough consumer acceptance study, including larger and more diverse panels, would help identify the most acceptable formulations and guide future product developments.

In conclusion, the study provides valuable insights into the potential of chickpea flour and pumpkin seed powder as functional ingredients for high-protein snacks. These snacks offer a promising alternative to conventional products, with enhanced nutritional value and appealing sensory qualities. The findings of this research contribute to the growing body of knowledge on plant-based functional foods and provide a foundation for the further development and commercialization of healthy snack options. Future studies should focus on refining the formulation and investigating longer-term shelf life, while continuing to explore the diverse applications of chickpea and pumpkin seed-based products in the food industry.

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